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## Abstract

The likely Reducing Emissions from Deforestation and Degradation (REDD+) mechanism includes strategies for the enhancement of forest carbon stocks. Recent concerns have been expressed that such enhancement, or restoration, of forest carbon could be counterproductive to biodiversity conservation, because forests are managed as “carbon farms” with the application of intensive silvicultural management that could homogenize diverse degraded rainforests. Restoration increases regeneration rates in degraded forest compared to naturally regenerating forest, and thus could yield significant financial returns for carbon sequestered. Here, we argue that such forest restoration projects are, in fact, likely to provide a number of benefits to biodiversity conservation including the retention of biodiversity, the prevention of forest conversion to agriculture, and employment opportunities for poor local communities. As with other forms of forest-based carbon offsets, there are possible moral hazard and leakage problems with restoration. However, due to the multiple benefits, we urge that enhancement of forest carbon stocks be detailed as a major component in the future negotiations of REDD+.

## Introduction

On December 18, 2009, the international community finalized the Copenhagen Accord—a nonbinding political statement that outlines principles to curb global warming to 2°C. The Accord was, therefore, a far call from a comprehensive agreement, but nevertheless progress was made on the inclusion of payments for habitat protection—known as Reducing Emissions from Deforestation and Degradation (REDD+). While REDD+ is still relatively undefined, the existing guidance provided by the *Bali Action Plan* states that acceptable mitigation interventions in developing countries are (1) avoided deforestation and degradation, (2) conservation and sustainable forest management, and (3) enhancement of forest carbon stocks (UNFCCC 2007).

The biodiversity benefits of reducing forest loss and improving forest management are generally accepted, but there is concern that the enhancement of carbon profiles via forest “restoration” has potentially negative consequences for biodiversity (Putz & Redford 2009; Sasaki & Putz 2009). In the case of degraded forested lands, restoration seeks to increase regeneration rates of native tree species persisting in the diverse seedling and sapling banks (Berry *et al.* 2008), via cutting back vegetation that chokes out regeneration, as well as “enrichment planting” of native tree saplings. The increase in plant growth rate compared to the rate of natural forest succession results in the biosequestration of additional atmospheric carbon, which will eventually be saleable under REDD+ and voluntary carbon offset markets. Concerns about restoration as a REDD+ mechanism stem from the blanket application of forest silviculture treatments to reduce competition from climbers, shrubs, and pioneer trees. Such intensive activities could be viewed as “carbon farming” (Putz & Redford 2009), resulting in a homogenization of the landscape and with negative consequences for biodiversity protection. Additionally, the selective choice of tree species planted to enrich the carbon profile could be viewed as conversion of a degraded, yet biodiverse, forest toward a plantation-like habitat (Putz & Redford 2009).

## Restoration of degraded primary forest

Concerns about mechanisms to enhance forest carbon stocks and "carbon farming" are certainly valid with respect to the intensity and scope of management treatments (Ludwig *et al.* 1993). However, we contend that restoration of degraded primary forests, such as those that have been selectively logged or burned, can play a critical role in restoring carbon profiles and protecting biodiversity, while providing socio-economic co-benefits. In particular

(1) The restoration of degraded primary forests provides two pathways for climate change mitigation. First, degraded forests are highly threatened, and much more likely to be converted to agriculture across the tropics than other forests (Rudel 2007; Koh & Wilcove 2008). Consequently, restoration projects protect existing carbon pools by avoiding conversion. For instance, clearance of logged lands to oil palm comes at a high carbon cost (Gibbs *et al.* 2008). Second, restoration accelerates the rate of carbon sequestration both by releasing remaining trees from competing vegetation (de Graaf *et al.* 1999; Finegan & Camacho 1999; Dauber *et al.* 2005; Wadsworth & Zweede 2006; Peña-Claros *et al.* 2008; Villegas *et al.* 2009) and by enrichment planting of selected seedlings (Ådjers *et al.* 1995; Fredericksen & Putz 2003; Pariona *et al.* 2003; Schulze 2008).

(2) Degraded forests retain a large proportion of biodiversity found in undisturbed habitat and are widely considered to be critical components of the global conservation strategy (Meijard & Sheil 2007; Dent & Wright 2009; Berry *et al.* 2010; Edwards *et al.* 2010). Recent evidence shows that intensive restoration via both liberation cutting of vines and enrichment planting in logged forest in Borneo has minimal negative effects on avifaunal communities and, in fact, appears to increase species richness of birds in degraded habitat to levels found in unlogged forests and to retain species of particular conservation concern (Edwards *et al.* 2009; Ansell *et al.* in press). Furthermore, a recent meta-analysis of 89 restoration projects suggests that these activities typically enhance biodiversity and ecosystem service provision (Rey Benayas *et al.* 2009).

(3) The tree species for enrichment planting can be carefully chosen to ensure the regeneration of a diverse and native mix of tree species, including those that have declined as a result of targeted timber extraction (Berry *et al.* 2008). Of course, it is highly likely that the biodiversity benefits of restoration would be undermined if enrichment planting involved the selection of nonnative trees species or promoted a monoculture.

(4) Forests support livelihoods of over one billion people in extreme poverty (World Bank 2004), providing important sources of food, fuelwood, and wild fodder, and over 20% of the total income of the rural poor (Appiah *et al.* 2007; Vedeld *et al.* 2007). In addition to these benefits, restoration offers potential for the employment of local people to conduct management interventions, and might also improve the provision of ecosystem services (Chazdon 2008), such as reduced soil erosion. Furthermore, the provision of livelihood benefits, including employment, are likely to increase the possibility of local buy-in to forest conservation (Dietz *et al.* 2003; Smith & Scherr 2003; Sachs *et al.* 2009), which is pivotal in ensuring long-term carbon sequestration and storage (Chhatre & Agrawal 2009).

Despite the benefits of restoration as a mitigation strategy, there are potential reasons for concern. There exists a moral hazard if carbon credits promote further timber extraction from logged rainforests before these forests are restored. One way around this issue might be to prevent newly degraded lands from qualifying for restoration credits, or weighting credits based on historical degradation rates. The latter suggests that the compensation of restoring a newly degraded piece of land be based on a past, averaged degradation rate (Strassburg *et al.* 2009). Restoration would also not overcome the leakage issue, where demand for agricultural land is simply pushed to areas without restoration projects, but this could be overcome by tying projects into national strategies for reducing "net" emissions. These impediments are not exclusive to restoration and similar moral hazard and leakage issues also exist for other REDD+ approaches (Koh 2009).

Since degraded and secondary forests comprise five of the 11 million km$^2$ of the world's remaining tropical forests (ITTO 2002), there is great scope to expand restoration across the tropics (Kettle 2010). Furthermore, in the event that biodiversity value is incorporated into the carbon market (e.g., Bekessy & Wintle 2008; Miles & Kapos 2008; Putz & Redford 2009), well-managed restoration projects in degraded forest would likely represent a biodiversity-friendly strategy. This is in contrast to reforestation with exotic tree plantations, which has limited benefits for biodiversity (Barlow *et al.* 2007), and afforestation on native nonforest habitats, such as species-rich grasslands, which causes a dramatic loss of biodiversity (Putz & Redford 2009).

## Conclusion

Restoration represents an important addition to the portfolio of forest-based carbon mitigation strategies for developing nations. Pivotally, restoration management of degraded forests does not appear to have negative consequences for biodiversity, while it provides the considerable benefit of protecting degraded lands and the species they contain against the significant threat of conversion to agriculture such as oil palm and soya. We thus urge that the role of restoration be detailed as a major component in the future negotiations of REDD+.

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